

## CLAIMS

What is claimed is:

1. A system for use with a horizontal directional drilling machine to monitor the position and orientation of a downhole tool assembly, the system comprising:

a first beacon supported by the downhole tool assembly having at least one orientation sensor and adapted to transmit signals indicative of the position and orientation of the downhole tool assembly;

a second beacon supported by the downhole tool assembly and spatially separated from the first beacon, wherein the second beacon has at least one orientation sensor and is adapted to transmit signals indicative of the position and orientation of the downhole tool assembly; and

a receiving assembly comprising:

an antenna arrangement adapted to detect signals emanating from the first beacon and the second beacon;

a processor supported by the receiving assembly and adapted to receive the detected signals, to process the detected signals, to generate a composite of the relative positions of the receiving assembly and the downhole tool assembly; and

a display adapted to visually communicate to composite of the relative positions of the receiving assembly and the downhole tool assembly and the orientation of the first beacon and of the second beacon.

2. A horizontal directional drilling system comprising:

a frame;

a drill string having a first end and a second end;

a rotary drive system attachable to the frame, operatively connectable to the first  
5 end of the drill string, and adapted to rotate and advance the drill string;

a downhole tool assembly comprising:

a bearing housing assembly connectable to the second end of the drill  
string;

a first beacon supported by the bearing housing assembly for movement  
10 therewith and adapted to transmit signals indicative of the  
orientation of the bearing housing assembly;

a front housing connectable to the bearing housing assembly and rotatable  
independently of the bearing housing assembly;

a second beacon assembly supported by the front housing for movement  
15 therewith and adapted to transmit signals indicative of the  
orientation of the front housing; and

a receiving assembly adapted to monitor the orientation of the bearing housing  
assembly and the front housing, the receiving assembly comprising:

an antenna assembly adapted to detect the signals emanating from both the  
20 first beacon and the second beacon and to transmit the detected  
signals; and

a processor assembly adapted to receive the detected signals from the  
antenna assembly, to process the detected signals to determine the  
orientation of the front housing and the orientation of the bearing  
25 housing assembly.

3. A downhole tool assembly for use with a rotatable drill string comprising:  
a rotatable bearing housing assembly connectable to the second end of the  
rotatable drill string;  
a first beacon supported by the bearing housing assembly for movement therewith  
and adapted to transmit signals indicative of the orientation of the bearing  
housing assembly;  
a front housing connectable to the bearing housing assembly and rotatable  
independently of the bearing housing assembly; and  
a second beacon assembly supported by the front housing for movement therewith  
and adapted to transmit signals indicative of the orientation of the front  
housing.

4. A method for drilling a borehole using a downhole tool assembly and a receiving assembly, the downhole tool assembly comprising a first beacon and a second beacon both supported by the downhole tool assembly, wherein the first beacon is adapted to transmit a first locating signal and wherein the second beacon is adapted to transmit a second locating  
5 signal, the method comprising:

sensing the first locating signal emanating from the first beacon and the second  
locating signal emanating from the second beacon; and  
processing the sensed first and second locating signals to generate a composite of  
the relative position of the receiving assembly to the first beacon and the  
10 second beacon.

5. A method for drilling a borehole having a desired pitch using a downhole tool assembly and a signal receiving assembly, the downhole tool assembly comprising a first beacon adapted to emit a first pitch signal indicative of the pitch orientation of the first beacon and a second beacon spatially separated from the first beacon and adapted to emit a second pitch  
5 signal indicative of the pitch orientation of the second beacon, the method comprising:  
sensing the first pitch signal and the second pitch signal using the signal receiving assembly;  
processing the first pitch signal and the second pitch signal substantially  
10 simultaneously to determine the pitch orientation of the first beacon and the pitch orientation of the second beacon; and  
comparing the pitch of the first beacon and the pitch of the second beacon to the desired pitch.